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DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

AERONAUTICAL RESEARCH LABORATORY

MELBOURNE, VICTORIA

Aircraft Structures Technical Memorandum 584

DEVELOPMENT OF A MENU DRIVEN MATERIALS DATA BASE
FOR USE ON PERSONAL COMPUTERS

by

R.H. KAYE

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SUMMARY

This Memorandum presents a PC based, menu driven materials data base for the engineering related properties of advanced structural materials. General materials information and suppliers' details are also provided. Data retrieval is performed by a TURBO PASCAL program of less than 100 lines, accessing several separate text files. This program will run under most MSDOS installations. Response time and accessing time is negligible on any IBM XT (or faster) machine and a graphics adaptor is not required.

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CONTENTS

1. INTRODUCTION

This work was undertaken to provide a PC based reference tool for use within the Aircraft Structures and Materials Division of the Aeronautical Research Laboratory, for the mechanical properties and suppliers of the composite materials and adhesives routinely used in the Division. For maximum portability, the package was developed to run on machines using MS-DOS and to use a modest amount of disk space and RAM. Elaborate graphics displays and other cosmetic features were not required. However, the software was required to be robust if not crash-proof. The task of comprehensively validating the data provided is beyond the scope of this initial report. As with all materials properties data the information provided should be regarded with caution.

2. STRATEGY FOR THE INITIAL DEVELOPMENT

The language TURBO PASCAL was chosen for this task. It is an easy language to use, MS-DOS specific and offers easy access to operating system functions from within the code.

The programming task is simplified if data searching is performed using the MS-DOS file accessing facilities. The data access time was optimised by using separate files for each section of data. The program was further simplified restricting each section of data to one screen full of text.

To simplify data entry and editing the data file was constructed in an ASCII (text-with-line-breaks) format. This enables a range of text editors to be used.

2.1 Menus File Listing

For ease of editing and programming, the text of the menus was also written as a. ASCII file. An identification number was placed above each menu so that its place in the menu tree could be determined. The first digit gives the level number (ie. 1 for the main menu, 2 for the next level down etc.). The other digit is the option number chosen from the root menu to select that menu (ie. the path to the menu). Menu number 30 is used for the default menu at level three.

The menu file contains all of the menu text and also determines the structure of the menu tree. It can be edited to add, delete and change options without any changes being made to the program. The current limitations are as follows:
a) Option 5 in the root menu always displays file 500 directly.
b) Menu 30 always comes up at level three and extra levels are not allowed for.
The menu file is listed in Appendix 1.

3. DATA RETRIEVAL SOFTWARE

The program performs the functions in the following order:

> a) Reads in all the menus.
>
> b) Writes the appropriate menus to screen
>
> c) Reads in the user responses
>
> d) Constructs a file name from these responses and displays that file on the screen.

It was decided that the error checking of user responses would be simpler if they were limited to single keystroke entries. Consequently, the user input options were limited to digits from 1 to 9. Three single digit option choices are read in and assembled to make a three character file name. For this particular program a file name extension was considered unnecessary for the data files.

4. PROGRAM LISTINGS

The first listing provided (Appendix 2) contains the current version of the program. This reveals the small size and the simplicity of the program.

As part of documenting this work an extensively commented version of the program was also produced. (See Appendix 3.) Some variables have been renamed but otherwise the two listings are identical.

5. DATA LISTINGS

A listing of the relevant data files is provided in Appendix 4. The main sources of information for these data files were the Aerospace Structural Metals Handbook [1], and the materials manufacturers data sheets. It is believed there is scope to improve the quality of the information.

6. CONCLUSION

A menu driven materials data base, for the purpose of a quick reference to the engineering-related properties of aircraft structural materials has been developed. General materials information, and suppliers details, are also provided. Data retrieval is performed by a TURBO PASCAL program of less than 100 lines accessing several separate text files. This simple application will run under most MSDOS installations.

REFERENCE

1. Aerospace Structural Metals Handbook, Aeronautical Systems Division, Wright Patterson Airforce Base, March 1963.

APPENDIX 1

MENUS FILE LISTING

10
MATERIALS DATA
1. ALUMINIUM ALLOYS
2. STEELS
3. COMPOSITES (ADVANCED FIBER REINFORCED PLASTICS)
4. EPOXY ADHESIVES
5. SUMMARY OF ALL MATERIALS IN 1, 2, 3 ABOVE.
21
ALUMINIUM ALLOYS
1. 2014   (DURAL TYPE ALLOY WITH SILICON, 65 KSI)
2. 2024   (DURAL TYPE HIGH STRENGTH ALLOY WITH COPPER, 71 KSI)
3. 7075   (CORROSION RESISTANT HIGH STRENGTH ALLOY WITH ZINC, 75 KSI)
4. 7178   (ULTRA HIGH STRENGTH ALLOY, SMALL THICKNESSES ONLY, 82 KSI)
22
STEELS
1. CORTEN   (A COMMON N. AMERICAN STRUCTURAL STEEL, 70 KSI)
2. AS1204   (A COMMON GROUP OF AUSTRALIAN STRUCTURAL STEELS, 70 KSI)
3. 4340   (LOW ALLOY HIGH STRENGTH STEEL, 230 KSI)
4. D6AC   (LOW ALLOY HIGH STRENGTH STEEL, 240 KSI)
5. 18 NI MIRAGING (HIGH NICKEL AND COBALT, HIGH STRENGTH STEEL, 300 KSI)
23
COMPOSITES (ADVANCED FIBER REINFORCED PLASTICS)
1. BORON/EPOXY   B5521/4 UNIDIRECTIONAL PREPREG
2. GRAPHITE/EPOXY XAS-914   UNIDIRECTIONAL PREPREG
3. GRAPHITE/EPOXY AS/3501-6 UNIDIRECTIONAL PREPREG
4. INCIDENTALS
24
EPOXY ADHESIVES
1. FM 73
2. FM 300
3. FM 300-2 INTERLEAF ADHESIVE
30
TYPE OF DATA REQUIRED
1. GENERAL INFORMATION
2. PHYSICAL AND MECHANICAL PROPERTIES
3. DETAILS OF SUPPLIERS

APPENDIX 2

COMPACT PROGRAM LISTING

```
Program MDB;
uses  crt;
label level1,level2,level3,shutdown,display;
var   options,code,nlines,nmen,temp,i,j,k        :integer;
      w,ch1,ch2,ch3      :char;
      menus              :array [1..100] of string[80];
      nline              :array [1..100] of integer;
      s2                 :string[2];
      control            :string[4];
      aline              :string[80];
      inm,int            :text;
procedure readmenus;
begin
 assign(inm,'menus'); reset(inm);
 i:=0;
 repeat
  i:=i+1;
  readln(inm,aline);
  s2:=copy(aline,1,2);  val(s2,temp,code);
  if temp>9 then begin nmen:=temp; readln(inm,aline);
end,
  nline[i]:=nmen; menus[i]:=aline;
 until eof(inm);
 nlines:=i; close(inm);
end;
procedure getmenu(var ch:char);
label readakey;
begin
clrscr; j:=0;
for i:=1 to nlines do if nline[i]=nmen then begin
 writeln(menus[i]); writeln; j:=j+1;
end;
options:=j-1;
writeln('Please select from 1 - ',options:1,' above.');
writeln; writeln('q   to quit');
if nmen<>10 then writeln('m   for main menu');
if nmen<>10 then writeln('esc for last menu');
readakey:
repeat
 ch:=readkey;                   {Keep reading in responses}
 if ch=#0 then begin ch:=readkey; goto readakey; end;
until (ch<>#0) and (ord(ch) in
[49..options+48,81,113,77,109,27]);
control:='null';               {Check for control type
responses}
if ord(ch) =  27       then control:='last';
if ord(ch) in [77,109] then control:='main';
if ord(ch) in [81,113] then control:='quit';
end;
```

```
procedure showdata;
label closeshowdata;
var
 i    :integer;       s3  :string[3];       s79 :string[79];
begin
 clrscr;
 s3:=ch1+ch2+ch3;
 assign(int,s3); {$I-} reset(int); {$I+}
 if ioresult<>0 then begin
  for i:=1 to 12 do writeln;
  writeln('            THIS DATA IS NOT YET AVAILABLE.');
  goto closeshowdata;
 end;
 repeat
  readln(int,s79);  writeln;  write(s79);
 until eof(int);
 close(int);
 closeshowdata:
 repeat
  w:=readkey;
  if w=#0 then begin w:=readkey; goto closeshowdata; end;
 until ord(w) in [81,113,77,109,27];
 if ord(w) =  27       then control:='last';
 if ord(w) in [77,109] then control:='main';
 if ord(w) in [81,113] then control:='quit';
end;
begin
 readmenus;
 level1:
 nmen:=10; getmenu(ch1);
 if control='last' then goto level1;
 if control='main' then goto level1;
 if control='quit' then goto shutdown;
 if ch1='5' then begin ch2:='0'; ch3:='0'; goto display;
end;
 level2:
 val('2'+ch1,nmen,code);  getmenu(ch2);
 if control='last' then goto level1;
 if control='main' then goto level1;
 if control='quit' then goto shutdown;
 level3:
 nmen:=30;  getmenu(ch3);
 if control='last' then goto level2;
 if control='main' then goto level1;
 if control='quit' then goto shutdown;
 display:
 showdata;
 if control='last' then
  if ch1='5' then goto level1 else goto level3;
 if control='main' then goto level1;
 if control='quit' then goto shutdown;
 shutdown: clrscr;
end.
```

APPENDIX 3

EXPANDED PROGRAM LISTING

```pascal
PROGRAM MDB;            {Program header statement.}

USES                    {The uses command links the crt unit in with the}
                        {code below. No other library code is used in this program}

 crt;                   {crt is a library of compiled procedures that control}
                        {the CRT (Cathode Ray Tube, ie. VDU). This library is only}
                        {needed for the more unusual VDU and keyboard operations}
                        {and all the default operations that are associated with}
                        {read and write statements do not require this library.}
                        {It has only been used here so as to provide the readkey}
                        {function which reads a single stroke entry from the}
                        {keyboard without any echo on the screen, or pause for a}
                        {'return' keystroke.}

LABEL
 level1,
 level2,                {These labels are used mainly by goto statements.}
 level3,                {'goto shutdown' is a more comprehensible}
 shutdown,              {statement than, for example, 'GOTO 17203'.}
 display,
 readakey;

VAR
                        {All variables are declared here with the exception of}
                        {those that are declared as local to a procedure which}
                        {are declared in that procedure.}
                        {This is a convenient place to comment in the}
                        {purpose of each variable, so as to avoid having to draw up}
                        {separate nomenclature documentation. The first letter of a}
                        {variable name has no special significance in TURBO PASCAL.}

 inm        :text;      {Input ASCII file containing all menus (called menus)}
                        {File variables are used to direct input/output}
                        {operations. They are similar to FORTRAN unit numbers}

 ind        :text;      {Input ASCII file containing materials data.}
                        {There are many of these files on disk but only one}
                        {is assigned to this file variable at any time.}
                        {They have a name consisting of a 3 digit number and}
                        {are all less than 25 lines long ie one screen of text}

 menus      :array [1..100] of string[80]; {Array to hold the menus, ie the}
                                           {entire contents of the menus fil·

 menumap    :array [1..100] of integer;    {Array to hold the menu number}
                                           {for each row of the menus array}

 control    :string[4]; {Variable which controls movement from one menu level}
                        {to another. Can be 'main','last' or 'quit'.}
                        {String type variables hold alpha-numeric}
                        {strings of up to 255 characters. Un-used trailing}
                        {string locations are ignored and the length of a}
                        {string depends only on what has been assigned to it.}

 options    :integer;   {Number of options in a menu, All user input}
                        {to this program is limited to single stroke entries.}
                        {Therefore the range for this variable is 1 - 9.}

 nlines     :integer;   {Number of lines in the file containing menus.}

 nmenu      :integer;   {Menu number. Identifies a menu by the path to it.}

 valerr     :integer;   {Variable to indicate error outcome, if any, after}
                        {the execution of a val procedure. val is a procedure}
                        {that converts string values into real or integer}

 ch1,ch2,ch3  :char;    {These variables store the digit characters of the}
                        {user menu selections and when all assigned are used}
                        {to identify the data file to be displayed}
                        {char is a single character type.}

 aline      :string[79];{String variable to hold one line of text}

 i,j,k      :integer;   {Counters for loops etc. Doesnt matter if not used.}

 i2         :integer;   {Two digit integer used for temporary storage.}

 s2         :string[2]; {Two character string variable for temporary storage.}

 w          :char;      {Used in conjunction with the readkey function to}
                        {suspend execution by waiting for a user key stroke}
```

```
PROCEDURE READMENUS;                    {Subroutines come before the main routine. If the main}
                                        {routine is regarded as a level 1 routine then this would be a}
                                        {level 2 routine. It reads menus from disk file and stores in the}
                                        {array called menus. It also creates a list of menu numbers to}
                                        {indicate which menu each line is from. This is stored in}
                                        {array menumap.}
begin
 assign(inm,'menus');                   {Opens file called 'menus' and assigns it to inm file variable}
 reset(inm);                            {Initialises file for reading from the top.}
 i:=0;                                  {Initialises counter for counting number of lines in inm file}
 repeat                                 {Start loop}
  i:=i+1;
  readln(inm,aline);                    {Reads a line from inm and puts it in string variable aline.}
  s2:=copy(aline,1,2);                  {Picks a sub-string from aline starting from the first}
                                        {character of length 2 characters and puts this in s2}
  val(s2,i2,valerr);                    {Converts s2 to an integer and puts in i2.}
  if (valerr=0) and (i2>9) then begin   {If i2 is a menu number}
   nmenu:=i2;                           {Put i2 in nmenu}
   readln(inm,aline); end;              {Skip this line}   {See listing of menus file}
  menumap[i]:=nmenu;
  menus[i]:=aline;
 until eof(inm);                        {Stop this loop when end of menus file is reached}
 nlines:=i;                             {Value in i will be number of rows in arrays menus and menumap}
 close(inm);                            {Close menus file}
end;


PROCEDURE GETMENU (VAR ch:char);        {This is another level 2 subroutine which writes the}
                                        {appropriate menu to screen and reads the user response.}
                                        {It also locks out all incorrect responses.}
                                        {The VAR statement declares ch as a variable local to this}
                                        {procedure and as a parameter to passed to the calling routine.}

LABEL readakey;

begin
clrscr;                                 {Clrscr is a procedure from the crt unit which clears the screen}
                                        {and puts the cursor in the top left corner.}
j:=0;                                   {j is a counter for the number of lines in a menu}
for i:=1 to nlines do
 if menumap[i]=nmenu then begin         {nmenu has been set by the calling routine.}
  writeln(menus[i]);                    {Writes the menu to the screen line by line}
  writeln;                              {Writes a blank line to the screen between each menu line.}
  j:=j+1;
 end;
options:=j-1;                           {The first line of the menu is the heading. All remaining lines}
                                        {are option lines, 1 option per line.}
writeln('Please select from 1 - ',options:1,' above.');
                                        {options:1 means write the value of options with a 1 digit field
width}
writeln;                                {Blank line}
writeln('q   to quit');
if nmenu<>10 then
 writeln('m   for main menu');          {If it is not the main menu then offer the 'm' option}
if nmenu<>10 then
 writeln('esc for last menu');          {If it is not the main menu then offer the escape option}

readakey:                               {Label for goto statement.}
repeat
 ch:=readkey;                           {Keep reading in responses until a good one is found}
 if ch=#0 then begin                    {Checks for a non-ASCII key ie. a cursor movement key.}
  ch:=readkey;                          {Non-ASCII keys send a second number (extended key code).}
  goto readakey;
 end;
until ord(ch) in [49..options+48,81,113,77,109,27];
                                        {This line checks for a character with an ASCII value in the}
                                        {list given. '49..options+48' refers to ASCII values of the}
                                        {acceptable digits (.. specifies a range of values).}
                                        {The square brackets specify a set of values.}
control:='null';
if ord(ch) =  27      then control:='last';    {Escape key}
if ord(ch) in [77,109] then control:='main';   {'M' or 'm'}
if ord(ch) in [81,113] then control:='quit';   {'Q' or 'q'}
                                        {Control is assigned on the basis of the ASCII number of ch.}
end;
```

```
PROCEDURE showdata;                              {This is the third and last level 2 subroutine}
                                                 {It gets the appropriate data file from disk and writes it}
                                                 {to screen. It also gives a message if the file is not present}
                                                 {in the current directory}

LABEL readakey;

VAR
  fname :string[3];                              {Name of data file to be displayed (local variable).}

begin
  clrscr;
  fname:=ch1+ch2+ch3;                            {ch1, ch2 and ch3 are the menu selections that have been chosen.}
  assign(ind,fname);                             {Assigns fname to the file variable ind}
  {$I-} reset(ind); {$I+}                        {The reset command is where the file is first accessed.}
                                                 {The terms before and after prevent the program crashing if the}
                                                 {file is not found.}
  if ioresult=0 then begin                       {ioresult will be 0 if the file has been found.}
   repeat
    readln(ind,aline);
    writeln;                                     {writeln writes from the current cursor position to the end of}
                                                 {the line and puts the cursor at the beginning of the next line.}
                                                 {This writeln is to write the remainder of the line from the}
                                                 {previous iteration. It has been done this way to prevent the}
                                                 {cursor going to the next line after the last line and so causing}
                                                 {line 1 to be scrolled off the top of the screen if it is full.}
    write(aline);                                {write leaves the cursor at the end of the written data}
                                                 {Because aline is a maximum of 79 characters there is always}
                                                 {at least 1 space left}
   until eof(ind);                               {Loop is stoped when end of file is reached}
   close(ind);
  end
  else begin                                     {ioresult will be non-zero if the file is not found.}
   for i:=1 to 12 do writeln;                    {12 blank lines.}
   writeln('                        THIS DATA IS NOT YET AVAILABLE.');
  end;                                           {Message is written to screen.}

  readakey:
  repeat
   w:=readkey;
   if w=#0 then begin w:=readkey; goto readakey; end;
  until ord(w) in [81,113,77,109,27];
  if ord(w) =  27       then control:='last';
  if ord(w) in [77,109] then control:='main';
  if ord(w) in [81,113] then control:='quit';
                                                 {The above statements are same as the read character statements}
                                                 {in the last routine except digits are not an acceptable entry}
end;

BEGIN                                            {Main program starts here.}
  readmenus;                                     {This is a call statement to the readmenus procedure.}

  level1:
  nmenu:=10;                                     {10 is menu number for main menu}
  getmenu(ch1);                                  {Display menu and put response in ch1}
  if control='quit' then goto shutdown;
  if ch1='5' then begin                          {For option 5 of the main menu there are no further menus.}
   ch2:='0'; ch3:='0';
   goto display;                                 {File 500 is displayed after choosing 5}
  end;

  level2:
  val('2'+ch1,nmenu,valerr);                     {nmenu is assigned from the string '2'+ch1. ie 21,22,23 or 24}
  getmenu(ch2);                                  {The level 2 menu is displayed and the response put in ch2}
  if control='last' then goto level1;
  if control='main' then goto level1;
  if control='quit' then goto shutdown;

  level3:
  nmenu:=30;                                     {The level three menu is always menu 30}
  getmenu(ch3);                                  {Display menu 30 and put response in ch3}
  if control='last' then goto level2;
  if control='main' then goto level1;
  if control='quit' then goto shutdown;

  display:
  showdata;                                      {Call procedure showdata. It uses ch1, ch2 & ch3}
  if control='last' then
   if ch1='5' then goto level1 else goto level3;
                                                 {Go back and write last menu again. If 5 was chosen at the main}
                                                 {menu then the main menu is the last menu.}
  if control='main' then goto level1;
  if control='quit' then goto shutdown;

  shutdown:
  clrscr; end.
```

APPENDIX 4

MATERIALS DATA FILES LISTINGS

******************** Materials Data File 111 ********************
ALUMINIUM ALLOY 2014 - GENERAL INFORMATION
THIS IS A DURAL TYPE AL ALLOY IN WHICH SILICON IS ADDED A HARDENER
ALONG WITH COPPER, MAGNESUIM AND MANGANESE. THE ALLOY IS AVAILABLE IN PLATE
BAR, TUBE, EXTRUDED SHAPES AND FORGINGS. IT HAS GOOD FORMING ABILITY
AND MAY BE RESISTANCE WELDED. THE T3 AND T4 HEAT TREATMENTS OF THIS ALLOY
HAVE SUPERIOR FORMING ABILITY OVER AL 2024 DUE TO A SLOWER AGEING RATE.

```
   COMPOSITION % (BY MASS)              HEAT TREATMENTS AVAILABLE

COPPER        3.90 - 5.00          0  T3  T4  T6  T42  T451  T651
MAGNESUIM     0.20 - 0.80
MANGANESE     0.40 - 1.20
IRON               1.00            NB: SHEET, STRIP & PLATE ARE CLAD WITH
SILICON       0.50 - 1.20          6003 OR 6053 FOR EXTRA CORROSION
CHROMIUM           0.10            RESISTANCE.
TITANIUM           0.15
OTHER              0.15
ALUMINIUM     REMAINDER
```

******************** Materials Data File 112 ********************
ALUMINIUM ALLOY 2014 - PHYSICAL AND MECHANICAL PROPERTIES

```
DENSITY                0.101     LB / CU IN
THERMAL EXPANSION      12.1      MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT          0.23      (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY   80 - 110  (BTU FT / HR SQFT) / 1 DEGREE F

TENSILE MODULUS        10700     KSI AT ROOM TEMP
                       11300     KSI AT -100 F
                       10400     KSI AT  200 F
```

PROPERTY	SHEET	SHEET & PLATE	WIRE, ROD, BAR		
	T3	T6,T651	T4,T457	T6,T651	
TENSILE ULTIMATE	59	64 - 67	55	65	KSI
TENSILE YEILD	35	57 - 59	32	55	KSI

TENSILE ULTIMATE STRAIN   APPROX 8000 MICROSTRAIN AT ROOM TEMPERATURE

FRACTURE TOUGHNESS   APPROX 22 KSI ROOT IN
                                 FOR LARGE THICKNESSES AT ROOM TEMPERATURES.
                                 (CAN BE 4 TIMES AS MUCH AT SMALL THICKNESSES)

******************** Materials Data File 113 ********************
ALUMINIUM ALLOY - SUPPLIERS

ALUMINIUM COMPANY OF AMERICA (ALCOA)   TD MATERIALS INC.
PO BOX 8025   303 N GLENOAKS BLVD
BETTENDORF IA 52722   BURBANK CA 91502
(319) 344 3000   (818) 848 4900

PIONEER ALUMINIUM INC.   BENEDICT MILLER INC.
3800 E 26TH ST.   340 MARIN AVE & ORIENT WAY
PO BOX 23947   PO BOX 912
LOS ANGELES CA 90023-0947   LYNDHURST NJ 07071
(213) 268 7211   (201)438 4000

UNIVERSAL ALLOY CORP.   GENERATION METALS INTL. LTD.
2871 LA MESA AVE   300 OSER AVE
PO BOX 6316   PO BOX ????
ANAHIEM CA 92816-6316   HAUPAUGE NY 11788
(714) 630-7200   (516) 273 0073

******************** Materials Data File 121 ********************
ALUMINIUM 2024 - GENERAL INFORMATION
AL 2024 HAS STRENGTH PROPERTIES IN VARIOUS TEMPERS THAT ARE AMONG THE HIGHEST
OBTAINABLE IN ALUMINIUM ALLOYS. IT IS THE MOST UNIVERSALLY USED HIGH STRENGTH
ALLOY AND IS AVAILABLE IN ALL WROUGHT FORMS EXCEPT FORGINGS. WHERE HIGHER
CORROSION RESISTANCE IS REQUIRED, CLAD 2024 SHEET AND STRIP IS PREFERRED OVER
THE BARE MATERIAL. THE ALLOY IS READILY FORMABLE, AND IN HEAT TREATED FORMS,
READILY MACHINABLE. THE ALLOY MAY BE RESISTANCE WELDED BUT FUSION WELDING
IS NOT GENERALLY RECOMMENDED.

```
   COMPOSITION % (BY MASS)                 HEAT TREATMENTS AVAILABLE

COPPER       3.80 - 4.90                      FOR SHEET AND PLATE
MAGNESUIM    1.20 - 1.80            0 T3 T36 T351 T4 T6 T81 T86 T851
MANGANESE    0.30 - 0.90
IRON             0.50                       FOR WIRE, ROD AND BAR
SILICON          0.50                   0 T4 T351 T6 T651 T851
CHROMIUM         0.10
OTHER            0.15
ALUMINIUM    REMAINDER
```

******************** Materials Data File 122 ********************
ALUMINIUM 2024 - PHYSICAL AND MECHANICAL PROPERTIES
```
DENSITY                 0.100      LB / CU IN
THERMAL EXPANSION       12.3       MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT           0.19       (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY    70 - 110   (BTU FT / HR SQFT) / 1 DEGREE F

TENSILE MODULUS         10700      KSI AT ROOM TEMP
                        11300      KSI AT -100 F
                        10400      KSI AT  200 F
```

```
PROPERTY            SHEET & PLATE           WIRE, ROD, BAR
TENSILE ULTIMATE      70 - 72                 62 - 66         KSI
TENSILE YEILD         64 - 68                 50 - 58         KSI
```

TENSILE ULTIMATE STRAIN   APPROX 8000 MICROSTRAIN AT ROOM TEMPERATURE

FRACTURE TOUGHNESS   APPROX 24 KSI ROOT IN
                               FOR LARGE THICKNESSES AT ROOM TEMPERATURES.
                               (CAN BE 4 TIMES AS MUCH AT SMALL THICKNESSES)

******************** Materials Data File 123 ********************
ALUMINIUM ALLOY - SUPPLIERS
```
ALUMINIUM COMPANY OF AMERICA (ALCOA)        TD MATERIALS INC.
PO BOX 8025                                 303 N GLENOAKS BLVD
BETTENDORF IA 52722                         BURBANK CA 91502
(319) 344 3000                              (818) 848 4900

PIONEER ALUMINIUM INC.                      BENEDICT MILLER INC.
3800 E 26TH ST.                             340 MARIN AVE & ORIENT WAY
PO BOX 23947                                PO BOX 912
LOS ANGELES CA 90023-0947                   LYNDHURST NJ 07071
(213) 268 7211                              (201)438 4000

UNIVERSAL ALLOY CORP.                       GENERATION METALS INTL. LTD.
2871 LA MESA AVE                            300 OSER AVE
PO BOX 6316                                 PO BOX ????
ANAHIEM CA 92816-6316                       HAUPAUGE NY 11788
(714) 630-7200                              (516) 273 0073
```

******************** Materials Data File 131 ********************
ALUMINIUM 7075 - GENERAL INFORMATION
THIS ALLOY COMBINES HIGH STRENGTH AND HIGH CORROSION RESISTANCE BUT IS
SUBJECT TO REDUCED PERFORMANCE AT ELEVATED TEMPERATURES. CORROSION RESISTANCE
IS INCREASED FURTHER BY CLADDING WITH A LOW ZINC ALLOY 7072. CLAD 7075 HAS
CORROSION RESISTANCE PROPERTIES AS GOOD AS PURE ALUMINIUM, HAS 95% OF THE
STRENGTH OF BARE 7075 AND BETTER FORMABILITY. THIS ALLOY CAN BE RESISTANCE
WELDED BUT FUSION WELDING IS NOT GENERALLY RECOMMENDED.

```
   COMPOSITION % (BY MASS)          HEAT TREATMENTS AVAILABLE
COPPER        1.20 - 2.00              0   T6   T651
MAGNESUIM     2.10 - 2.90
MANGANESE         0.30
IRON              0.70
SILICON           0.50
ZINC          5.10 - 6.10
CHROMIUM      0.18 - 0.40
TITANIUM          0.20
OTHER             0.15
ALUMINIUM     REMAINDER
```

******************** Materials Data File 132 ********************
ALUMINIUM 7075 - PHYSICAL AND MECHANICAL PROPERTIES
```
DENSITY                0.101     LB / CU IN
THERMAL EXPANSION      12.7      MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT          0.21      (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY   80 - 110  (BTU FT / HR SQFT) / 1 DEGREE F


TENSILE MODULUS        10700     KSI AT ROOM TEMP
                       11300     KSI AT -100 F
                       10400     KSI AT  200 F
```

```
PROPERTY               SHEET & PLATE          WIRE, ROD, BAR
TENSILE ULTIMATE       70 - 77                    77          KSI
TENSILE YEILD          62 - 66                    66          KSI
```

TENSILE ULTIMATE STRAIN   APPROX 8000 MICROSTRAIN AT ROOM TEMPERATURE

FRACTURE TOUGHNESS   APPROX 22 KSI ROOT IN
                             FOR LARGE THICKNESSES AT ROOM TEMPERATURES.
                             (CAN BE 4 TIMES AS MUCH AT SMALL THICKNESSES)

******************** Materials Data File 133 ********************
ALUMINIUM ALLOY - SUPPLIERS
```
ALUMINIUM COMPANY OF AMERICA (ALCOA)       TD MATERIALS INC.
PO BOX 8025                                303 N GLENOAKS BLVD
BETTENDORF IA 52722                        BURBANK CA 91502
(319) 344 3000                             (818) 848 4900


PIONEER ALUMINIUM INC.                     BENEDICT MILLER INC.
3800 E 26TH ST.                            340 MARIN AVE & ORIENT WAY
PO BOX 23947                               PO BOX 912
LOS ANGELES CA 90023-0947                  LYNDHURST NJ 07071
(213) 268 7211                             (201)438 4000


UNIVERSAL ALLOY CORP.                      GENERATION METALS INTL. LTD.
2871 LA MESA AVE                           300 OSER AVE
PO BOX 6316                                PO BOX ????
ANAHIEM CA 92816-6316                      HAUPAUGE NY 11788
(714) 630-7200                             (516) 273 0073
```

******************** Materials Data File 141 ********************
ALUMINIUM 7178 - GENERAL INFORMATION
THIS IS ALLOY HAS EXCELLENT STRENGTH PROPERTIES AND GENERAL PROPERTIES
SIMILAR TO 7075. ITS USE IS GENERALLY LIMITED TO THICKNESSES OF 1.5" MAX
FOR PLATE AND 0.75" FOR EXTRUSIONS. SPECIAL CARE MUST BE TAKEN TO OBTAIN
FULL AGE HARDENING IN THIS ALLOY.

```
   COMPOSITION % (BY MASS)              HEAT TREATMENTS AVAILABLE
COPPER        1.60 - 2.40           SHEET:           0 T6 T651
MAGNESUIM     2.40 - 3.10           EXTRUDED FORMS:  0 T6 T6510 T6511
MANGANESE         0.30
IRON              0.70              SHEET, STRIP AND PLATE CAN BE CLAD WIT
SILICON           0.50              7072 FOR EXTRA CORROSION RESISTANCE
ZINC          6.30 - 7.30
CHROMIUM      0.18 - 0.40
TITANIUM          0.20
OTHER             0.15
ALUMINIUM     REMAINDER
```

******************** Materials Data File 142 ********************
ALUMINIUM 7178 - PHYSICAL AND MECHANICAL PROPERTIES
DENSITY   0.102   LB / CU IN
THERMAL EXPANSION   12.5   MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT   0.23   (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY 80 - 110   (BTU FT / HR SQFT) / 1 DEGREE F

TENSILE MODULUS   10700   KSI AT ROOM TEMP
                        11300   KSI AT -100 F
                        10400   KSI AT 200 F

```
PROPERTY              SHEET & PLATE        WIRE, ROD, BAR
TENSILE ULTIMATE          88                   97          KSI
TENSILE YEILD             78                   86          KSI
```

TENSILE ULTIMATE STRAIN   APPROX 8100 MICROSTRAIN AT ROOM TEMPERATURE

FRACTURE TOUGHNESS   APPROX 21 KSI ROOT IN
                               FOR LARGE THICKNESSES AT ROOM TEMPERATURES.
                               (CAN BE 4 TIMES AS MUCH AT SMALL THICKNESSES)

******************** Materials Data File 143 ********************
ALUMINIUM ALLOY - SUPPLIERS
ALUMINIUM COMPANY OF AMERICA (ALCOA)   TD MATERIALS INC.
PO BOX 8025   303 N GLENOAKS BLVD
BETTENDORF IA 52722   BURBANK CA 91502
(319) 344 3000   (818) 848 4900

PIONEER ALUMINIUM INC.   BENEDICT MILLER INC.
3800 E 26TH ST.   340 MARIN AVE & ORIENT WAY
PO BOX 23947   PO BOX 912
LOS ANGELES CA 90023-0947   LYNDHURST NJ 07071
(213) 268 7211   (201)438 4000

UNIVERSAL ALLOY CORP.   GENERATION METALS INTL. LTD.
2871 LA MESA AVE   300 OSER AVE
PO BOX 6316   PO BOX ????
ANAHIEM CA 92816-6316   HAUPAUGE NY 11788
(714) 630-7200   (516) 273 0073

******************** Materials Data File 211 ********************
CORTEN STRUCTURAL STEEL - GENERAL INFORMATION
THIS LOW CARBON, LOW ALLOY STEEL IS TYPICAL OF THOSE HAVING A TOTAL ALLOY
CONTENT LESS THAN ABOUT 2.5%. IT IS NOT HEAT TREATABLE BUT IN THE ANNEALED
OR NORMALIZED CONDITION IT IS CONSIDERABLY STRONGER THAN PLAIN CARBON STEEL
AND HAS SUPERIOR CORROSION RESISTANCE. IT IS EASILY FORMED AND WELDED.

```
   COMPOSITION % (BY MASS)
CARBON             0.12
CHROMIUM      0.30 - 1.25
COPPER        0.25 - 0.55
MANGANESE     0.20 - 0.50
NICKEL             0.65
SILICON       0.25 - 0.75
PHOSPHORUS    0.07 - 0.15
SULFUR             0.05
IRON          REMAINDER
```

******************** Materials Data File 212 ********************
CORTEN STRUCTURAL STEEL - PHYSICAL AND MECHANICAL PROPERTIES

```
DENSITY               0.284      LB / CU IN
THERMAL EXPANSION     6.30       MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE


TENSILE MODULUS       28000 - 30000     KSI


TENSILE ULTIMATE         78.4    KSI
TENSILE YIELD            60.6    KSI
TENSILE ULTIMATE STRAIN  180000  MICROSTRAIN
```

******************** Materials Data File 213 ********************
AIRCRAFT STEELS - SUPPLIERS

BOWSTEEL OF AMERICA
722 FRELINGHUYSEN AVE
NEWARK NJ 07114-1343
(201) 824 8296

FANSTEEL INC
1 TANTALUM PLACE
NORTH CHICAGO IL 60064
(708) 689 4900

BETHLEHEM STEEL CORP
SGO BUILDING
BETHLEHEM PA 18016-7699
(215) 694 2424

LADISH CO
5481 S. PACKARD AVE
CUDAHY WI 53110
(414) 747 2611

CANNON-MUSKEGON CORP
2875 LINCOLN ST
MUSKEGON MI 49441
(616) 755 4016

LATROBE STEEL CO.
2626 LIGONIER ST
LATROBE PA 15650
(412) 537 7711

DP METAL PRODUCTS
(ALABON PRECISION MFG CORP)
1040 HOME ST
BRONX NY 10459
(212) 589 5682

PITTSBURGH FORGINGS
301 THORN ST
CORAOPOLIS PA 15108
(412) 264 4000

******************** Materials Data File 221 ********************
AS1205 STRUCTURAL STEELS - GENERAL INFORMATION
AS1205 IS THE NUMBER OF THE AUSTRALIAN STANDARD THAT SPECIFIES THIS STEEL.
BEING A LOW CARBON, LOW ALLOY STEEL IT IS TYPICAL OF THOSE HAVING A TOTAL ALLO
CONTENT LESS THAN ABOUT 2.5%. IT IS NOT HEAT TREATABLE, BUT IN THE ANNEALED
OR NORMALIZED CONDITION IT IS CONSIDERABLY STRONGER THAN PLAIN CARBON STEEL
AND HAS SUPERIOR CORROSION RESISTANCE. IT IS EASILY FORMED AND WELDED, AND
VERY SIMILAR TO CORTEN, A COMMON NORTH AMERICAN STRUCTURAL STEEL.

```
   COMPOSITION % (BY MASS)
CARBON            0.12
CHROMIUM      0.40 - 1.00
COPPER        0.15 - 0.45
MANGANESE         1.00
NICKEL            0.50
SILICON       0.20 - 0.70
PHOSPHORUS    0.06 - 0.15
SULFUR            0.04
IRON          REMAINDER
```

******************** Materials Data File 222 ********************
AS1205 STRUCTURAL STEELS - PHYSICAL AND MECHANICAL PROPERTIES
DENSITY   0.284   LB / CU IN
THERMAL EXPANSION   6.30   MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE

TENSILE MODULUS   28000 - 30000   KSI

TENSILE ULTIMATE   76.2   KSI
TENSILE YIELD   57.0   KSI
TENSILE ULTIMATE STRAIN 180000 MICROSTRAIN

******************** Materials Data File 223 ********************
AIRCRAFT STEELS - SUPPLIERS

BOWSTEEL OF AMERICA   FANSTEEL INC
722 FRELINGHUYSEN AVE   1 TANTALUM PLACE
NEWARK NJ 07114-1343   NORTH CHICAGO IL 60064
(201) 824 8296   (708) 689 4900

BETHLEHEM STEEL CORP   LADISH CO
SGO BUILDING   5481 S. PACKARD AVE
BETHLEHEM PA 18016-7699   CUDAHY WI 53110
(215) 694 2424   (414) 747 2611

CANNON-MUSKEGON CORP   LATROBE STEEL CO.
2875 LINCOLN ST   2626 LIGONIER ST
MUSKEGON MI 49441   LATROBE PA 15650
(616) 755 4016   (412) 537 7711

DP METAL PRODUCTS   PITTSBURGH FORGINGS
(ALABON PRECISION MFG CORP)   301 THORN ST
1040 HOME ST   CORAOPOLIS PA 15108
BRONX NY 10459   (412) 264 4000
(212) 589 5682

******************** Materials Data File 231 ********************
4340 ULTRA HIGH STRENGTH STEEL - GENERAL INFORMATION
4340, INCLUDING ITS VARIETY 4337 WHICH HAS A SLIGHTLY LOWER CARBON CONTENT,
IS THE PREFERRED COMMON LOW ALLOY STEEL FOR AIR WEAPONS WHERE GOOD STRENGTH,
HIGH HARDENABILITY AND UNIFORMITY ARE DESIRED. IT CAN BE HEAT TREATED TO
STRENGTH VALUES WITHIN A WIDE RANGE. AT STRENGTH LEVELS UP TO ABOUT 200 KSI,
OTHER LOW ALLOY STEELS WITH SUFFICIENT HARDENABILITY POSSSS NEARLY THE SAME
MECHANICAL AND OTHER PROPERTIES AS 4340. AT 200 - 220 KSI AND 260 - 280 KSI
THIS STEEL HAS BEEN FOUND TO BE SUPERIOR TO OTHER COMMON LOW ALLOY STEELS,
AND ALSO TO SOME OF THE RECENTLY DEVELOPED MORE COMPLEX LOW ALLOY ULTRA HIGH
STRENGTH STEELS. 4340 IS AVAILABLE IN ALL WROUGHT FORMS AND CASTINGS. IT
POSSESSES A FAIR FORMABILITY WHEN PROPERLY ANNEALED AND CAN BE WELDED BY
VARIOUS METHODS. FORGINGS IN THIS ALLOY HEAT TREATED TO 260 - 280 KSI REQUIRE
SPECIAL MEASURES IN DESIGN AND FABRICATION.

```
   COMPOSITION     % (BY MASS)
CARBON            0.38 - 0.43
CHROMIUM          0.70 - 0.90
MANGANESE         0.65 - 0.85
MOLYBDENUM        0.20 - 0.30
NICKEL            1.65 - 2.00
SILICON           0.20 - 0.30
PHOSPHORUS             0.04
SULFUR                0.04
IRON            REMAINDER
```

******************** Materials Data File 232 ********************
4340 ULTRA HIGH STRENGTH STEEL - PHYSICAL AND MECHANICAL PROPERTIES

```
DENSITY                0.284    LB / CU IN
THERMAL EXPANSION      6.30     MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT          0.107    (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY   21.7     BTU FT / HR SQFT / 1 DEGREE F


TENSILE MODULUS        30000    KSI AT ROOM TEMP
                       28000    KSI AT 400 F
```

HEAT TREATMENT	125	150	180	200	260	
TENSILE ULTIMATE	125	150	180	200	260	KSI
TENSILE YIELD	103	132	163	176	217	KSI
TENSILE ULTIMATE STRAIN	230000	185000	150000	135000	-	MICROSTRAIN

```
FRACTURE TOUGHNESS          50 - 170 KSI ROOT IN
```

******************** Materials Data File 233 ********************
AIRCRAFT STEELS - SUPPLIERS

BOWSTEEL OF AMERICA
722 FRELINGHUYSEN AVE
NEWARK NJ 07114-1343
(201) 824 8296

BETHLEHEM STEEL CORP
SGO BUILDING
BETHLEHEM PA 18016-7699
(215) 694 2424

CANNON-MUSKEGON CORP
2875 LINCOLN ST
MUSKEGON MI 49441
(616) 755 4016

DP METAL PRODUCTS
(ALABON PRECISION MFG CORP)
1040 HOME ST
BRONX NY 10459

FANSTEEL INC
1 TANTALUM PLACE
NORTH CHICAGO IL 60064
(708) 689 4900

LADISH CO
5481 S. PACKARD AVE
CUDAHY WI 53110
(414) 747 2611

LATROBE STEEL CO.
2626 LIGONIER ST
LATROBE PA 15650
(412) 537 7711

PITTSBURGH FORGINGS
301 THORN ST
CORAOPOLIS PA 15108
(412) 264 4000

******************** Materials Data File 241 ********************
D6AC STEEL - GENERAL INFORMATION
THIS LOW ALLOY HIGH STRENGTH STEEL ORIGINALLY DEVELOPED FOR HOT WORK DIE
APPLICATIONS HAS FOUND CONSIDERABLE USE AS A STRUCTURAL MATERIAL IN THE
AIRCRAFT AND MISSILE INDUSTRY. IT MAY BE HEAT TREATED TO STRENGTH LEVELS
OF UP TO 300 KSI AND TEMPERS BELOW 240 KSI HAVE EXCELLENT TOUGHNESS.
TEMPERS BELOW 220 KSI ARE SUITABLE FOR APPLICATIONS IN TEMPERATURES UP TO
900 F. THE ALLOY MAY BE READILY WELDED AND COLD FORMED IN THE ANNEALED OR
SPHEROIDIZED CONDITION. D6AC STEEL IS ELECTRIC FURNACE AIR MELTED AND REMELTED
BY VACUUM CONSUMABLE ELECTRODE. A VARIATION IS D6AV STEEL WHICH IS VACUUM
DEGASSED.

```
   COMPOSITION % (BY MASS)                    WELDING
CARBON          0.46        THIS ALLOY IS WELDABLE IN HEAVY SECTIONS
CHROMIUM        1.00        BY EMPLOYING TECNIQUES NORMALLY USED FOR
MANGANESE       0.75        WELDING HIGH HARDENABILITY MEDIUM CARBON
MOLYBDENUM      1.00        LOW ALLOY STEEL.
NICKEL          0.55
SILICON         0.22
IRON            REMAINDER
```

******************** Materials Data File 242 ********************
D6AC STEEL - PHYSICAL AND MECHANICAL PROPERTIES
```
DENSITY                0.284     LB / CU IN
THERMAL EXPANSION      7.38      MICROSTRAIN / 1 DEGREE F AT ROOM TEMPERATURE
SPECIFIC HEAT         *0.107     (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY   350       BTU / HR SQFT / 1 DEGREE F /IN
                       *THE VALUE GIVEN IS FOR SAE 4140


TENSILE MODULUS        30000     KSI AT ROOM TEMP
                       25000     KSI AT 400 F
```

TEMPERING TEMPERATURE F	300	400	500	600	700	800	900
TENSILE ULTIMATE KSI	339	303	287	275	258	245	230
TENSILE YIELD KSI	240	248	254	246	237	230	221
TENSILE ULTIMATE STRAIN IN MICROSTRAIN	98000	103000	100000	106000	107000	109000	13200

FRACTURE TOUGHNESS   50 - 170 KSI ROOT IN

******************** Materials Data File 243 ********************
AIRCRAFT STEELS - SUPPLIERS

BOWSTEEL OF AMERICA   FANSTEEL INC
722 FRELINGHUYSEN AVE   1 TANTALUM PLACE
NEWARK NJ 07114-1342   NORTH CHICAGO IL 60064
(201) 824 8296   (708) 689 4900

BETHLEHEM STEEL CORP   LADISH CO
SGO BUILDING   5481 S. PACKARD AVE
BETHLEHEM PA 18016-7699   CUDAHY WI 53110
(215) 694 2424   (414) 747 2611

CANNON-MUSKEGON CORP   LATROBE STEEL CO.
2875 LINCOLN ST   2626 LIGONIER ST
MUSKEGON MI 49441   LATROBE PA 15650
(616) 755 4016   (412) 537 7711

DP METAL PRODUCTS   PITTSBURGH FORGINGS
(ALABON PRECISION MFG CORP)   301 THORN ST
1040 HOME ST   CORAOPOLIS PA 15108
BRONX NY 10459   (412) 264 4000
(212) 589 5682

******************** Materials Data File 251 ********************
18 NI MARAGING STEEL - GENERAL INFORMATION
THIS STEEL IS ONE OF THE MARAGING TYPES WHICH CAN DEVELOP YIELD STRENG
OVER 300 KSI, PRIMARILY AS A RESULT OF A COMPLEX PRECIPITATION IN A VE   W
CARBON MARTENSITE. THE MARAGING STEELS WERE DESIGNED SPECIFICALLY TO F
SUPERIOR RESISTANCE TO UNSTABLE CRACK PROPAGATION AT HIGH STRENGTH LEV
THREE COMPOSITION RANGES ARE AVAILABLE CORRESPONDING TO TYPICAL YIELD   NGTH
GRADES OF 250, 300 AND 350 KSI. IT IS IMPORTANT TO NOTE THAT THE ACTUA
STRENGTH LEVEL WILL VARY WITH THE COMPOSITION LIMITS IN A GIVEN GRADE.
FORMABILITY IS GOOD IN THE ANNEALED CONDITION AND WELDING CHARACTERIST
APPEAR VERY SATISFACTORY, PROVIDING THAT PROPER TECHNIQUES ARE USED. C   ION
AND OXIDATION RESISTANCE ARE SOMEWHAT BETTER THAN 4340.

```
   COMPOSITION (FOR 300 KSI TEMPER)   % (BY MASS)
CARBON                                    0.03
MANGANESE                                 0.10
MOLYBDENUM                          3.0 - 3.5
NICKEL                             18.0 - 19.0
SILICON                                   0.10
PHOSPHORUS                                0.01
SULFUR                                    0.01
COBALT                              8.5 - 9.5
TITANIUM                            0.5 - 0.8
ALUMINIUM                          0.05 - 0.15
IRON                               REMAINDER
```

******************** Materials Data File 252 ********************
18 NI MARAGING STEEL - PHYSICAL AND MECHANICAL PROPERTIES
```
DENSITY               0.289      LB / CU IN
THERMAL EXPANSION     5.6        MICROSTRAIN / 1 DEGREE F AT ROOM TEMP      PE
SPECIFIC HEAT         0.1        (BTU / LB) / 1 DEGREE F
THERMAL CONDUCTIVITY  350        BTU / HR SQFT / 1 DEGREE F /IN
TENSILE MODULUS       26000 - 28000    KSI AT ROOM TEMP
POISSONS RATIO             0.30        ALL GRADES
TENSILE ULTIMATE  KSI     250 - 350 KSI DEPENDING ON COMPOSITION AND
TENSILE YIELD  KSI        240 - 330 KSI DEPENDING ON COMPOSITION AND
TENSILE ULTIMATE STRAIN 100000 - 140000 MICROSTRAIN
FRACTURE TOUGHNESS        30 - 170 KSI ROOT IN
```

******************** Materials Data File 253 ********************
AIRCRAFT STEELS - SUPPLIERS

BOWSTEEL OF AMERICA   FANSTEEL INC
722 FRELINGHUYSEN AVE   1 TANTALUM PLACE
NEWARK NJ 07114-1343   NORTH CHICAGO IL 60064
(201) 824 8296   (708) 689 4900

BETHLEHEM STEEL CORP   LADISH CO
SGO BUILDING   5481 S. PACKARD AVE
BETHLEHEM PA 18016-7699   CUDAHY WI 53110
(215) 694 2424   (414) 747 2611

CANNON-MUSKEGON CORP   LATROBE STEEL CO.
2875 LINCOLN ST   2626 LIGONIER ST
MUSKEGON MI 49441   LATROBE PA 15650
(616) 755 4016   (412) 537 7711

DP METAL PRODUCTS   PITTSBURGH FORGINGS
(ALABON PRECISION MFG CORP)   301 THORN ST
1040 HOME ST   CORAOPOLIS PA 15108
BRONX NY 10459   (412) 264 4000
(212) 589 5682

******************** Materials Data File 311 ********************
BORON EPOXY 5521/4 - GENERAL INFORMATION
5521/4 IS A HIGHLY ADVANCED PREPREG TAPE MATERIAL WHICH COMBINES
BORON FILAMENTS OF 4 MIL DIAMETER WITH A TOUGH, RIGID, HIGH-TEMPERATURE
EPOXY RESIN. THE TAPE IS USED FOR FABRICATION OF COMPOSITE STRUCTURES
WHICH CAN PERFORM AT TEMPERATURES UP TO 250 F WITH EXCEPTIONAL STRENGTH
AND STIFFNESS AT MINIMUM WEIGHT.

PREPREG CHARACTERISTICS
RESIN CONTENT   33%   +/- 2%   FILAMENTS LAY SIDE BY SIDE
LAMINATE FLOW   14%   +/- 5%   ONE LAYER ONLY LENGTH-WISE
VOLATILE CONTENT   1.5%   ALONG THE ROLL. BACKING FILM
TACK 73 F   GOOD   PROTECTS THE PRODUCT ON THE
WIDTH TOLERANCE   +/- 0.02 IN   ROLL.
FILAMENT COUNT   208 / IN
ROLL LENGTH (TYPICAL)   500 FT   TAPE WIDTHS AVAILABLE
STORAGE TEMPERATURE   0 F   UP TO 6 IN, 0.25 IN STEPS
SHELF LIFE   12 MONTHS AT 0 F

******************** Materials Data File 312 ********************
BORON EPOXY 5521/4 - PHYSICAL AND MECHANICAL PROPERTIES
DENSITY   0.072 LB / CU IN
THERMAL EXPANSION   2.5   MICROSTRAIN / 1 DEGREE F

TYPICAL MATERIAL PROPERTIES

TEMP (F)	E11	E22	G12	V12
-60	29600.	3400.	1030.	0.18
RM/TMP	30900.	2900.	1100.	0.18
180 (WET)	30900.	1910.	274.	0.18

TYPICAL STRENGTHS

TEMP	FIBRE TENSION	TRANSVERSE TENSION	TRANSVERSE COMPRESSION	SHEAR STRESS
F	KSI	KSI	KSI	KSI
-60	167.	8.13	196.	15.3
RM/TEMP	169.	6.7	175.	10.1
180	159.	5.26	107.	8.1

THE 180 F STRENGTH VALUES ARE FOR HOT WET CONDITIONS.

******************** Materials Data File 313 ********************
BORON EPOXY - SUPPLIERS
TEXTRON SPECIALITY MATERIALS
2 INDUSTRIAL AVENUE
LOWELL
MASSACHUSETTS, MA 01851
USA

******************** Materials Data File 321 ********************
GRAPHITE/EPOXY 'CIBA-GEIGY XAS/914 GRAPHITE PREPREG' - GENERAL INFORMATION
XAS/914 IS A 350 F CURING MODIFIED EPOXY RESIN PREIMPREGNATED ON
GRAPHITE FABRIC OR UNIDIRECTIONAL TAPE. IT WAS DEVELOPED FOR USE AS A
STRUCTURAL PREPREG IN PRIMARY STRUCTURES. IT IS USED WIDELY IN
SPOILERS, AILERONS RUDDER ASSEMBLIES, ELEVATORS AND STABILISERS. IT
HAS GOOD APPLICATION CHARACTERISTICS WITH A TOLERANCE OF THE
VARIATIONS EXPECTED IN GENERAL PRODUCTION PRACTICE. IT HAS HIGH MELT
VISCOSITY AND IS SUITABLE FOR HIGH OR MEDIUM PRESSURE LAMINATING. IT
HAS GOOD STRENGTH RETENTION IN THE RANGE OF SERVICE TEMPERATURES -75
TO 380 F.

	UNIDIRECTIONAL TAPE	WOVEN FABRIC
RESIN CONTENT	37 +/- 2 %	40 +/- 2 %
VOLATILE CONTENT	1 % MAX	1 % MAX
FLOW (350 F, 100 PSI)	15 +/- 5 %	18 +/- 4 %
GEL TIME (AT 315 F)	15 +/- 5 MIN	15 +/- 5 MIN
SHELF LIFE	12 MONTHS AT 0 F	12 MONTHS AT 0
OUT TIME	3 MONTHS AT RT	3 MONTHS AT RT
CURED RESIN DENSITY	1.28 GM/CC	1.28 GM/CC
GLASS TRANSITION TEMPERATURE	350 F	350 F

XAS/914 IS AVAILABLE IN A WIDE VARIETY OF FIBER WEIGHTS AND A VARIETY OF FABRI
STYLES. RESIN CONTENTS MAY BE ADJUSTED TO MEET SPECIFIC REQUIREMENTS.

******************** Materials Data File 322 ********************
'CIBA-GEIGY XAS/914 GRAPHITE PREPREG' - PHYSICAL AND MECHANICAL PROPERTIES
DENSITY   0.06 LB / CU IN
                PROPERTIES FOR UNIDIRECTIONAL XAS/914 PREPREG TAPE

PROPERTY	TEMPERATURE (F)	DIRECTION	VALUE (KSI)
TENSILE STRENGTH	70	0	240
	70	90	11
	250	90	9
TENSILE MODULUS	70	0	20000
	70	90	1300
	250	90	1100
COMPRESSION STRENGTH	70	0	196
	250	0	140
	70	90	33
	250	90	19
SHEAR STRENGTH	70	INTERLAMINAR	14
	250	INTERLAMINAR	10
	360	INTERLAMINAR	6
POISSONS RATIO (NU12)	70	--	0.28
	250	--	0.28

******************** Materials Data File 323 ********************
CARBON/EPOXY - SUPPLIERS
CIBA-GEIGY CORP. COMPOSITE MATERIALS DEPT.
5115 EAST PALMA AVE
ANAHEIM CA 92807-2018
(714) 799 9000
AMOCO PERFORMANCE PRODUCTS INC.
38C GROVE ST
RIDGEFIELD CT 06877
(203) 431 1900
BASF STRUCTURAL MATERIALS INC.   CTL AEROSPACE INC
11501 STEEL CREEK ROAD   5616 SPELLMERE DR
PO BOX 7687   WORLD PARK, CINCINNATI, OH 45246
CHARLOTTE NC 28217-7687   (513) 874 7900
(704) 587 8290

******************** Materials Data File 331 ********************
GRAPHITE/EPOXY AS/3501-6 GRAPHITE PREPREG' - GENERAL INFORMATION
AS/3501-6 IS A 350 F CURING MODIFIED EPOXY RESIN PREIMPREGNATED ON GRAPHITE
FABRIC OR UNIDIRECTIONAL TAPE. IT WAS DEVELOPED FOR USE AS A STRUCTURAL
PREPREG IN PRIMARY STRUCTURES. IT IS USED WIDELY IN SPOILERS, AILERONS
RUDDER ASSEMBLIES, ELEVATORS AND STABILISERS. IT HAS GOOD APPLICATION
CHARACTERISTICS WITH A TOLERANCE OF THE VARIATIONS EXPECTED IN GENERAL
PRODUCTION PRACTICE. IT HAS HIGH MELT VISCOSITY AND IS SUITABLE FOR HIGH
OR MEDIUM PRESSURE LAMINATING. IT HAS GOOD STRENGTH RETENTION IN THE RANGE
OF SERVICE TEMPERATURES -75 TO 380 F.

	UNIDIRECTIONAL TAPE
RESIN CONTENT	42 +/- 3 %
VOLATILE CONTENT	1 % MAX
SHELF LIFE	12 MONTHS AT 0 F
OUT TIME	10 DAYS AT RT

AS/3501-6 IS AVAILABLE IN A WIDE VARIETY OF FIBER WEIGHTS AND A VARIETY OF
FABRI
STYLES. RESIN CONTENTS MAY BE ADJUSTED TO MEET SPECIFIC REQUIREMENTS.

******************** Materials Data File 332 ********************
 AS/3501-6 GRAPHITE PREPREG' - PHYSICAL AND MECHANICAL PROPERTIES
      TYPICAL PROPERTIES FOR UNIDIRECTIONAL AS/3501-6 PREPREG TAPE

PROPERTY	TEMPERATURE (F)	DIRECTION	VALUE (KSI)
TENSILE STRENGTH	70	0	273
	250	0	267
	70	90	9.5
	250	90	9.1
TENSILE MODULUS	70	0	20800
	250	0	20300
	70	90	1900
	250	90	1600
COMPRESSION STRENGTH	70	0	280
	250	0	227
	70	90	39
	250	90	27
SHEAR MODULUS	70	--	850
	250 (WET)	--	520
SHEAR STRENGTH	70	IN PLANE	17.3
POISSONS RATIO (NU12)	70	---	0.3
	250	---	0.3

******************** Materials Data File 333 ********************
AS 3501-6 GRAPHITE/EPOXY - SUPPLIERS
USA
HERCULES ADVANCED MATERIALS AND SYSTEMS COMPANY
COMPOSITE PRODUCTS DIVISION
BACCHUS WORKS
MAGNA,
UTAH, 84044-0098
PHN: (801)-250 5911

AUSTRALIA
AC-HATRIC CHEMICALS PL
STEPHEN RD
BOTANY, NSW 2019
AUSTRALIA

******************** Materials Data File 341 ********************
FOR INCIDENTAL MATERIALS USED IN THE MANUFACTURING PROCESSES SUCH AS
VACUUM BAGGING MATERIALS PREPREGS FOR TOOLING, NYLON BAGGING FILM,
VAC-VALVES AND HOSES RELEASE FILMS ,   POLYESTER FILLER PASTES,
BLEEDERS, PEEL PLIES, SEALANT TAPES, BREATHERS, ETC...

CONTACT :   AIRTECH INTERNATIONAL
             2542 EAST DEL AMO BLVD
             POST OFFICE BOX 6207
             CARSON, CALIFORNIA 90749,
             USA, PHONE (213)-603-9683

******************** Materials Data File 411 ********************
ADHESIVE FM 73 - GENERAL INFORMATION
FM 73 IS A HEAT CURED EPOXY ADHESIVE FILM AVAILABLE WITH TWO CARRIERS.
FM 73 IS SUPPLIED WITH A POLYESTER KNIT FABRIC WHICH OFFERS OPTIMUM PHYSICAL
PROPERTIES WHILE FM 73M WITH ITS RANDOM POLYESTER MAT CARRIER HAS SUPERIOR
HANDLING CHARACTERISTICS. SERVICEABLE OVER A TEMPERATURE RANGE OF -67 TO 250 F
(-55 TO 120 C), FM 73 IS FORMULATED FOR MOISTURE RESISTANCE AND IS SUITABLE FO
BONDING METALS AND MANY STRUCTURAL MATERIALS.
APPEARENCE: SUPPORTED, SLIGHTLY TACKY, YELLOW FILM
            (DARK GREEN IN 0.005 INCH THICKNESS ONLY)
            THICKNESSES OF 0.005, 0.007, 0.010, 0.015 INCHES
SHELF LIFE: SIX MONTHS FROM DATE OF SHIPMENT AT BELOW 40 F
            30 DAYS AT BELOW 75 F

******************** Materials Data File 412 ********************
ADHESIVE FM 73 - PHYSICAL AND MECHANICAL PROPERTIES
AREA DENSITY
0.030 lbs/sq ft for 0.005 inch thickness
0.045   0.007
0.060   0.010
0.085   0.015

TEMP	SHEAR MODULUS	SHEAR YIELD STRESS	SHEAR YIELD STRAIN	SHEAR ULTIMATE STRESS	SHEAR ULTIMATE STRAIN
F	KSI	KSI	IN/IN	KSI	
-67	131	3.350	0.026	8.080	0.447
75	122	2.510	0.021	5.930	0.873
140	66	1.460	0.022	5.060	1.430
180	38	0.980	0.028	5.150	1.623

ABOVE VALUES ARE FOR 0.06 PSF FM 73, USING BR 127 PRIMER.

******************** Materials Data File 413 ********************
ADHESIVE FM 73, SUPPLIERS
USA
AMERICAN CYANAMID COMPANY
POLYMER PRODUCTS DIVISION
ENGINEERED MATERIALS DEPARTMENT
AEROSPACE PRODUCTS
WAYNE NEW JERSEY 07470

AUSTRALIA
CYANAMID AUSTRALIA P/L
5 BUSINESS PARK DRIVE
NOTTING HILL
VICTORIA
HEAD OFFICE
5 GIBBON RD
BAULKHAM HILLS
NSW

******************** Materials Data File 421 ********************
ADHESIVE FM 300 - GENERAL INFORMATION
FM 300 IS A MODIFIED EPOXY FILM ADHESIVE AVAILABLE WITH THREE DIFFERENT
MOISTURE-RESISTANT POLYESTER CARRIERS. IT IS DESIGNED FOR BONDING METAL
TO METAL AND SANDWICH COMPOSITE STRUCTURES. IT HAS HIGH ELONGATION AND
TOUGHNESS WITH HIGH ULTIMATE SHEAR STRENGTH. THEREFORE IT IS PARTICULARLY
SUITABLE FOR REDISTRIBUTION OF HIGH SHEAR STRESS CONCENTRATIONS OF GRAPHITE
EPOXY TO METAL BONDS AS IT CAN ACCOMMODATE THE LOW INTERLAMINATE SHEAR
STRENGTH OF THE LAMINATE. IT IS PARTICULARLY GOOD IN FATIGUE RESISTANCE
IN THESE JOINTS. IN PROPERLY DESIGNED AND PROCESSED JOINTS THE TIGHT KNIT
TRICOT CARRIER PROVIDES A DEGREE OF ELECTRICAL ISOLATION BETWEEN THE METAL
AND THE GRAPHITE COMPOSITE TO REDUCE GALVANIC CORROSION.

VOLATILE	1% MAXIMUM
STANDARD WEIGHT	0.08 +/- 0.005 LB / SQ FT
NOMINAL THICKNESS	0.013 IN
SHOP LIFE	FIVE DAYS AT 90 F
SHELF LIFE	SIX MONTHS AT 0 F
SERVICE TEMPERATURES	-67 TO 300 F FOR STANDARD THICKNESS
CURE TEMPERATURE	350 F FOR 60 MINUTES
COLOUR	BLUE WITH TIGHT KNIT TRICOT CARRIER
	GREEN WITH RANDOM MAT CARRIER
	GREEN WITH WIDE OPEN KNIT CARRIER

******************** Materials Data File 422 ********************
ADHESIVE FM 300 - PHYSICAL AND MECHANICAL PROPERTIES
AREA DENSITY 0.08 +/- 0.005 LB / SQ FT FOR 0.013 IN STANDARD THICKNESS

TEST CONDITION	SANDWICH PEEL STRENGTH (IN LB / IN)		
	FM300	FM300K	FM300M
75 +/- 5 F	19	18	14
300 +/- 5 F	12	16	13
-67 +/- 5 F	17	13	11
	FLATWISE TEMSILE STRENGTH (PSI)		
75 +/- 5 F	875	1000	970
300 +/- 5 F	350	460	505
-67 +/- 5 F	965	1120	1030
	TENSILE SHEAR STRENGTH (PSI)		
75 +/- 5 F	5145	5340	4325
160 +/- 5 F	-	4775	4335
250 +/- 5 F	3935	3575	3360
300 +/- 5 F	2910	2967	2310
	TYPICAL SHEAR MODULUS (KSI)		
70 F	90.0		
220 F (DRY)	40.6		
220 F (1.5% MOISTURE)	27.0		

******************** Materials Data File 423 ********************
ADHESIVE FM 300, SUPPLIERS
USA
AMERICAN CYANAMID COMPANY
POLYMER PRODUCTS DIVISION
ENGINEERED MATERIALS DEPARTMENT
AEROSPACE PRODUCTS
WAYNE NEW JERSEY 07470
AUSTRALIA
CYANAMID AUSTRALIA P/L
5 BUSINESS PARK DRIVE
NOTTING HILL
VICTORIA

******************** Materials Data File 431 ********************
ADHESIVE FM 300-2 - GENERAL INFORMATION
FM 300-2 INTERLEAF ADHESIVE IS A HIGH STRAIN, LOW FLOW, MODIFIED EPOXY
ADHESIVE FILM DEVELOPED TO REDUCE SHEAR STRESS CONCENTRATIONS IN COMPOSITE
STRUCTURES. THE INTERLEAF IS DESIGNED TO REMAIN A DISCRETE LAYER THROUGH THE
COMPOSITE CURE CYCLE. INTERLEAVING AREAS OF HIGH SHEAR CONCENTRATIONS IN
COMPOSITE STRUCTURES SIGNIFICANTLY INCREASES ULTIMATE STRENGTH AND TOUGHNESS.
IN SURFACE PLY APPLICATIONS, FM 300-2 INTERLEAF ADHESIVE OFFERS AN EFFECTIVE
ALTERNATIVE FOR SMOOTHING AND FINISHING THE TOOL SIDE OF COMPOSITE PARTS
REDUCING THE NEED FOR SANDING AND FILLING OPERATIONS. IT CAN BE CO-CURED
WITH MOST 250 F AND 350 F EPOXY RESIN SYSTEMS. IT IS SUPPLIED AS EITHER
A SUPPORTED OR UNSUPPORTED FILM IN A VARIETY OF WEIGHTS.

NOMINAL WEIGHT (LB / SQ FT)	NOMINAL THICKNESS (IN)
0.030	0.005
0.050	0.008
0.080	0.013

VOLATILES	1 % MAX	SHELF LIFE	THREE MONTHS AT 40 F MAX
SHOP LIFE	10 DAYS AT 75 F	COLOUR	ORANGE

A STANDARD CURE CYCLE IS 30 TO 120 MINUTES AT 250 F THEN 60 MINUTES
AT 250 F, ALL AT 40 PSI.

******************** Materials Data File 432 ********************
ADHESIVE FM 300-2 - PHYSICAL AND MECHANICAL PROPERTIES

NOMINAL WEIGHT (LB / SQ FT)	NOMINAL THICKNESS (IN)
0.030	0.005
0.050	0.008
0.080	0.013

TEST CONDITION	FM300-2U 0.03 WEIGHT	FM300-2U 0.05 WEIGH
	LARGE AREA LAP SHEAR STRENGTH (PSI)	
-67 F	4200	5100
75 F	5770	6000
250 F	3630	4450
	BOEING CLIMBING DRUM PEEL (IN LB / IN)	
-67 F	18	14
75 F	37	34
250 F	39	38

SEE MANUFACTURERS DATA SHEETS FOR CO-CURE DETAILS.

******************** Materials Data File 433 ********************
ADHESIVE FM 300, SUPPLIERS
USA
AMERICAN CYANAMID COMPANY
POLYMER PRODUCTS DIVISION
ENGINEERED MATERIALS DEPARTMENT
AEROSPACE PRODUCTS
WAYNE NEW JERSEY 07470
AUSTRALIA
CYANAMID AUSTRALIA P/L
5 BUSINESS PARK DRIVE
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HEAD OFFICE
5 GIBBON RD
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NSW

```
******************** Materials Data File 500 ********************
              SUMMARY OF MATERIAL STRUCTURAL PROPERTIES
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MATERIAL	TENSILE STRENGTH KSI	TENSILE MODULUS KSI	STRENGTH/WEIGHT KSI / (LB / CU IN
ALUMINIUM ALLOYS			
2014	67	10700	663
2024	72	10700	720
7075	77	10700	762
7178	88	10700	862
STEELS			
CORTEN	78	28000	275
AS1204	77	28000	271
4340	200	28000	704
D6AC	280	30000	986
MARAGING	330	27000	1160
COMPOSITES			
BORON/EPOXY	210	31000	2920
CARBON/EPOXY	200*	20000*	3330*

```
*THESE FIGURES VARY A LOT DEPENDING ON WHICH PREPREG IS USED.
ALL THE VALUES ABOVE ARE PROVIDED AS A ROUGH GUIDE ONLY AND ARE SUBJECT TO
MANY DETAILS SUCH AS COMPOSITION, HEAT TREATMENT, THICKNESS, TEMPERATURE ETC.
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16. ABSTRACT
This Memorandum presents a PC based, menu driven materials data base for the engineering related properties of advanced structural materials. General materials information and suppliers' details are also provided. Data retrieval is performed by a TURBO PASCAL program of less than 100 lines, accessing several separate text files. This program will run under most MSDOS installations. Response time and accessing time is negligible on any IBM XT (or faster) machine and a graphics adaptor is not required.

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